

# **INVESTIGATION OF HEAT TRANSFER ENHANCEMENT WITH NANOFLUID AND TWISTED TAPE INSERTS IN A CIRCULAR TUBE**

By

**Nabeel Sameer Mahmoud Al-saady**

(B.Sc. Mechanical Eng. 1997, M.Sc. Refrigeration and Air conditioning, 2000)

*SUPERVISED BY*

**Prof. Dr. Abdulhassan A. Karamallah**

2014, (205Page)

## **Abstract**

This work presents an experimental and numerical study to investigate the heat transfer enhancement in a horizontal circular tube use three metal oxide {(ZrO<sub>2</sub> (80 nm),  $\gamma$  Al<sub>2</sub>O<sub>3</sub> (20 nm), CuO (40 nm))} – distilled water nanofluids with twisted tape. Three types of twisted tapes (typical twisted tape, twisted tape with V-cut and clockwise-counter clockwise twisted tape) were used with twist ratios (TR=4, 6, 8). The studied concentrations of nanofluids are ( $\phi$  = 0, 0.01, 0.05, 0.1, 0.5, 1, 2, 3% by volume) under fully developed turbulent flow and uniform heat flux condition.

The experimental test rig includes all the required instruments to study the heat transfer enhancement for three types of nanofluids with inserted twisted tape. All the tests were carried out with Reynolds number range (2490-20100) and uniform heat flux (2108-9280 W/m<sup>2</sup>).

The experimental study also includes preparation of nanofluids and measurement of properties of nanofluids, density, viscosity and specific heat. The pressure drop, wall temperature, flow rate, heat flux and temperature of nanofluids flowing through a uniform heated circular tube were measured.

The obtained maximum Nusselt number ratio ( $Nu_{\text{Twisted Tape}}/Nu_{\text{plain tube}}$ ) was (2.41) which occurred in clockwise-counter clockwise twisted tape with twist ratio ( $TR = 4$ ) at Reynolds number (2490), and the maximum thermal performance factor was (1.44) at Reynolds number (4981) using distilled water.

For nanofluid, the maximum enhancement in the heat transfer (the Nusselt number ratio ( $Nu_{\text{nanofluid}}/Nu_{\text{plain tube}}$ )) was (7.5), using with (CuO) – distilled water nanofluid, clockwise-counter clockwise twisted tape with twist ratio ( $TR=4$ ) at Reynolds number (2490) and concentration ( $\phi=3\%$ ). And the maximum thermal performance factor was (3.9) using (CuO) – distilled water nanofluid, clockwise-counter clockwise twisted tape with twist ratio ( $TR=4$ ) at Reynolds number (2490) and concentration ( $\phi=3\%$ ).

The average Nusselt number and friction factor with Reynolds number, nanofluid concentration and twist ratio were Correlated for each type of the used nanofluid.

The numerical analysis was based on finite volume numerical techniques to solve the governing partial differential equations in three dimensions, using ANSYS FLUENT commercial CFD software, to study the effect of Reynolds number, concentration of nanofluid, nanofluid types and twist ratio on the heat transfer enhancement, average Nusselt number, velocity profile, and skin friction for nanofluid.

The comparison between the experimental and numerical results shows a high agreement, and the maximum error was 10% occurred with (CuO) nanofluid, typical twisted tape, twist ratio ( $TR = 4$ ), and concentration ( $\phi=2\%$ ). The comparison of the present numerical and experimental results with the published work gives a good agreement.